Detection of Cloudiness from Temperature and Humidity Profiles for Different Resolution of Radiosonde Sounding by Various Methods

Irina V. Chernykh, Oleg A. Alduchov
Russian Research Institute of Hydrometeorological Information- Word Data Center, Obninsk, Russia,
E-mails: civ@meteo.ru , aoa@meteo.ru

In this paper analysis of resources of some methods (Smagorinsky, 1960; Dmitrieva-Arrago et al. 1969; Arabey-Moshnikov, 1975; Dubrovina, 1982; Chernykh and Eskridge, 1996; Dmitrieva-Arrago and Shatunova, 1999) for cloudiness determination from temperature (T) and humidity profiles for different resolution Δh of radiosonde sounding is presented.

The temperature and humidity profiles from GPS-sounding for 23:15 (UTC) 4 May 1998 during SHEBA experiment were used for research. Mixed low clouds with base near 700 m and top near 1100 m and almost dissipated middle clouds were observed about 22:00 (UTC), according aircraft NCAR C-130Q observations about 22:00 (UTC) and Radar data (Curry, 2000).

From original SHEBA-GPS soundings data with 1-2 m resolution profiles with distance between levels for Δh = 100, 200, 300, 400, 500, 600 and 700 m were obtained. These profiles were formed by some steps: on the first stage, only standard isobaric levels data were taken; on the next stages the significant levels for temperature and humidity were added to standard levels. This process to addition the significant levels for T and humidity was repeated until the distances between levels became not more than Δh. The values of the T and relative humidity were defined as significant, if it's derivative from linear function between two neighboring levels were more than 0.5 °C and 2.5 % respectively.

By Smagorinsky diagram (table 1), cloudiness with cloud amount 70% and 60% of the sky in the atmospheric layers 1000-800 hPa and 800-550 hPa was predicted for all Δh. High clouds (5-7% of the sky), was determined in the layer 550-300 hPa for Δh = 100, 200, 300, 400, and 700 m.

Methods, developed by Dmitrieva-Arrago-Shatunova and by Dubrovina, are based on using the critical values of dew point depression for existence cloudiness. Cloud boundaries, predicted by the methods were equivalent for all Δh (table 2). By these methods middle clouds were detected only for $\Delta h <$ 400 m, low clouds were predicted and high clouds were absent for all resolutions. Low clouds boundaries are in good agreement with aircraft observations.

Low, middle and high clouds were exist according by Arabey-Moshnikov diagram tables 3 and 4. Cloud layer base was detected at height about 300 m - 700 m (for different Δh) and the cloud top at about 4750 m (table 3). But different cloud amount was predicted for different sounding levels (table 4). Overcast was predicted at height about 700 m for all Δh. Else thin cloud layers with cloud amount 60-80% were predicted in atmospheric layer 5-8 km.

As it follows from tables 1-5, low clouds were detected by all methods for all sounding resolutions, but results, obtained by Arabey-Moshnikov diagram and Chernykh and Eskridge method (table 5), give more detailed vertical cloudiness structure and less depend from sounding resolution.

Table 1. Cloud amount (% of the sky), predicted in the atmospheric layers by Smagorinsky diagram for different Δh.

Atmospheric layer (hPa)	Δh (m)						
	100	200	300	400	500	600	700
1000-800	70%	70%	70%	70%	70%	70%	70%
800-550	60%	60%	60%	60%	60%	60%	60%
550-300	7%	7%	5%	4%	-	-	5%

Table 2. Cloud boundaries (m), predicted by Dmitrieva-Arrago and Shatunova, and Dubrovina methods for different Δh.

	Δh (m)						
	100	200	300	400	500	600	700
(hPa)	*Dmitrieva-Arrago-Shatunova* method						
1000-850	562-1202	562-1202	710-1071	710-1071	710-1071	710-1071	710-1071
850-500	2002-4559	2056-4559	2155-4559				
(km)	*Dubrovina* method						
0-2	562-1202	562-1202	710-1071	710-1071	710-1071	710-1071	710-1071
2-6	2002-4559	2056-4559	2155-4559				

Table 3. Cloud boundaries (m), predicted by *Arabey-Moshnikov* diagram for different Δh .

Δh (m)						
100	200	300	400	500	600	700
346-4752	419-4752	419-4752	419-4752	419-4752	710-4752	710-4752
5294-5490	5351-5490	5351-5490	5351	5351	5351	5351
6276-7078	6276-7016	6276-7016	6276-6892	6276-6892	6276-6644	6276-6644
7195-7469	7253-7469	7253-7469	7367	7369	7367	7367

Table 4. Cloud layers (m) or level and cloud amount (% of the sky), predicted by *Arabey-Moshnikov* diagram for different Δh , in atmospheric layer below 7000 m.

cloud amount (%)	Δh (m)						
	100	200	300	400	500	600	700
60-80	346-487	419	419	419	419		
80-100	562-1387	562-1330	709-1330	710-1330	710-1330	710-1330	710-1330
60-80	1443-3975	1443-3975	1443-3975	1558-3975	1558-3975	1558-3975	1558-3975
80-100	4070-4559	4168-4559	4168-4559	4168-4559	4364	4364	4364
60-80	4656-4752	4752	4752	4752	4752	4752	4752
60-80	5294-5490	5351-5490	5351-5490	5351	5351	5351	5351
60-80	6276-7078	6276-7016	6276-7016	6276-6892	6276-6892	6276-6644	6276-6644
60-80	7195-7469	7253-7469	7253-7469	7367	7369	7367	7367

Table 5. Cloud layers boundaries (m), predicted by Chernykh and Eskridge method for different $\Delta h / \Delta H$, Δh – sounding resolution, ΔH – minimal detected cloud layers thickness.

$\Delta h / \Delta H$ (m/m)						
100/50	200/100	300/100	400/100	500/100	600/100	700/100
273-367						
505-736	509-755	496-767				
818-909	928-1137	929-1223	775-1209	775-1209	775-1209	775-1209
1746-1823	1762-1870	1765-1879	1765-1878	1767-1900	1767-1898	1767-1898
1982-2053						
2064-2207	2024-2154	2089-2279	2088-2280	2344-2533	2279-2464	2279-2464
2703-2787						
2883-2959	2964-3104	2864-3087				
3659-3735	3714-3872	3714-3872				
3831-3913						
4042-4202	4051-4237	4051-4237	3917-4128	3917-4128	3919-4130	3919-4130
4430-4506	4490-4677	4490-4677	4554-4786	4554-4786	4553-4781	4553-4781
5334-5421	5234-5458	5244-5557	5246-5556	5246-5556	5245-5617	5245-5617
	6100-6223		6172-6889	6245-6839	6212-6832	6212-6832
6717-6810	6677-6867	6551-6876				
7298-7412	7288-7429	7242-7482	7243-7483	7251-7695	7250-7695	7250-7696

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